A Low Cost 1.2GHz Pre-Scaler

Ian Hickman describes a simple and inexpensive pre-scaler that can add a great deal of versatility to your bench frequency counter. Any PW 'Robin' frequency meter owners will find it particularly useful.

The project I'm going to describe, produces an economical, simple to construct pre-scaler. It can operate with input frequencies up to 1.2GHz.

The sensitivity of the pre-scaler, even at this frequency, is excellent, permitting fairly loose coupling to the source. The loose-coupling avoids excessive loading, which could otherwise affect the frequency of an oscillator or even stop it running altogether.

The key to the unit's low cost, is the use of a pre-scaler designed for use in the phase-lock loop forming part of the synthesiser in a Band IV/V TV receiver. These i.c.s are designed for consumer applications and are very modestly priced. They can often be pressed into service in applications such as this, for which they were never designed.

How It Works

Let's take a look at the process, and see how it works. The device we're going to use is the Siemens SDA4212. It's a dual-modulus pre-scaler which divides either by 64 or by 65, depending upon the state of a logic control line.

The dual-modulus facility is not required in this application, so the line is strapped permanently 'high' (connected to the chip's positive supply rail). This selects the divide by 64 mode.

A useful feature of this i.c. is the built-in input pre-amplifier, which provides high sensitivity. Fortunately it's equally happy with a large input signal, unlike some pre-scaler chips which only operate reliably over a fairly restricted range of input amplitude.

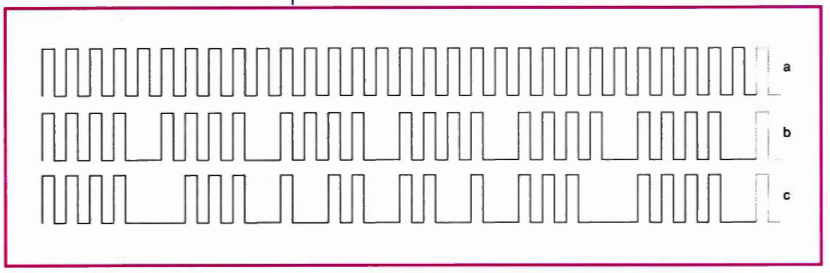
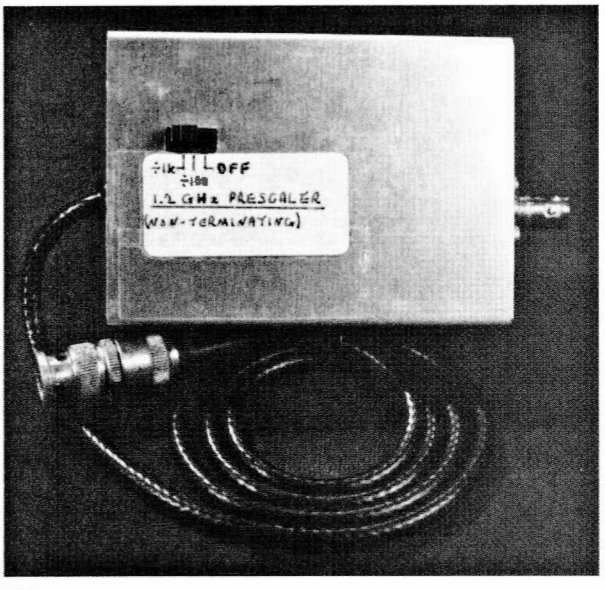


Fig. 1: Output pulse chart from the SDA4212 i.c. (see text).



Author's prototype pre-scaler. The final version of the project employs an off-board switch.

Division Ratio

To be useful as a pre-scaler to extend the range of a counter or frequency meter, a decimal division ratio such as 10:1 or 100:1 is needed. So, some lateral thinking is necessary in order to take advantage of the low cost and high sensitivity of the SDA4212 i.c.

In this case, we need to turn a division ratio of 64:1 into 100:1. This is achieved by using a divide-by-five stage to gate out every fifth pulse from the SDA4212's output.

Doing this twice over produces the desired result, as indicated in the output pulse chart I've provided in **Fig. 1**. Let's suppose, for the sake of example, that the waveform in **Fig. 1(a)**, is the output from the SDA4212 when fed with a 1GHz input.

With this example, the waveform (a) is at 1GHz x 1/64 or 15.625MHz. After the knock-out-one-pulse-in-five circuit, the frequency is 1GHz x 1/64 x 4/5 = 1GHz x 1/80 or 12.5MHz, as in **Fig. 1(b)**.

Repeating the process gives 1GHz x 1/80 *x* 4/5 = 1GHz x 1/100 or just 10MHz, as in **Fig. 1(c)**. Notice that in (b), the pulses are not all equally spaced, whilst in (c) the pattern is even more odd. However, this is of no consequence in the present application.

Finally, further divide-by-ten stages are incorporated. These give a choice of divide-by-100, divide-by-1000 or divide-by-10 000.

Magazine Circuit

The diagram, **Fig. 2,** shows the circuit of the pre-scaler. It's based on an application circuit, published in the Siemens company's house magazine, (ref. 1).

The unit is powered from a PP9 battery, and in view of the current drain, around 50mA, a rechargeable NiCad battery is recommended. When fully charged, a battery of this type will run the unit continuously for over an hour.

A 2.1mm power socket is incorporated in the design to enable the battery to be recharged without removing it from the unit. A d.c. source of about 18V is suitable for the purpose.

A suitable power source can be conveniently obtained from a 12V 300mA unregulated plug-top power supply. These power units will provide the best part of 18V when the load current drawn is only 10mA.

The charging input by-passes the switch, which will normally be in the **off** position during charging. The charger can be connected to the unit while it's in use. However, as the maximum recommended charging current for a NiCad PP3 style battery is only 10 or 12mA, the unit will not operate correctly with a flat battery. You must give it time to charge up first!

Three Legged Regulator

The d.c. supply from the battery is applied to a standard three-legged 7805 regulator. The earthy leg is 'propped' up on diode D5, to provide a stabilised output of about 5.5V. This extends the operating frequency range of the divide by 64 pre-scaler, IC1,

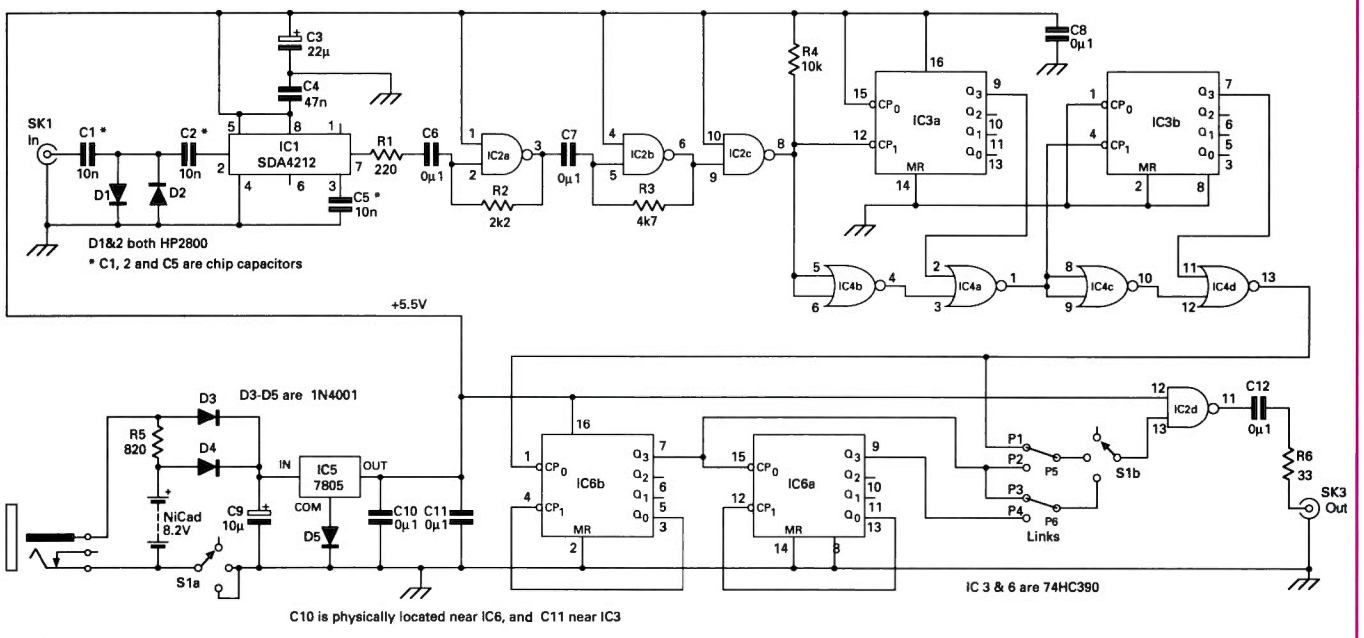


Fig. 2: Cicuit diagram of the 1.2GHz pre-scaler.

to about 1.2GHz.

The diode, D3, protects the regulator in the event of accidental reversed battery polarity connection. The stabilised output powers the e.c.l. (emitter coupled logic) pre-scaler IC1. It also supplies the four other i.c.s, which in the interests of battery economy are mostly c.m.o.s. (complimentary metal/oxide silicon) types.

The input signal at the input BNC socket, SK1, is applied via two 10nF capacitors in series to the pre-amplifier input of the pre-scaler chip. The pre-amplifier output is internally connected to the divider stages.

The two Schottky diodes, D1 and D2, protect IC1's input in the event of an excessive input voltage being applied. The output of IC1 is a.c. coupled via R1 and C6, to two stages of the quad two-input AND gate IC2, used with self bias as linear amplifiers.

Simple Inverter

The action just described, converts the e.c.l. output to a solid t.t.l. logic swing, while the 'pull-up' resistor, R4, at the output of the third AND gate, also used as a simple inverter, converts it to a full swing suitable for h.c.m.o.s. devices.

The output of the third AND gate is applied to the B input of a dual decade divider IC3, and also to a two-input OR gate, part of IC3. The output at Q (D) (pin 9) of IC3, is at one fifth of the frequency of the B input (the divide by 2 section with its A input at pin 15 is not used) and goes high during every fifth input pulse. This maintains the output at pin 1 of IC4 low for that pulse, so gating out one pulse in five.

The delay through the divide-by-five section of IC3, is compensated for by the delay through the OR gate in the clock frequency path (output at pin 4 of IC4). This process is repeated again using the second divide-by-5 section of IC3 together with the other two OR gates, giving an output of (F in) x 1/100 at pin 13 of IC4.

The output is applied to two cascaded divide-by-10 stages, comprising of IC6. With the links P1-P5 and P3-P6 as shown in **Fig. 2**, the three-position switch, S1, gives a choice of divide-by-100, divide-by-1000 and off.

Without Overflowing

The divide-by-1000 range enables frequencies above 1GHz to be displayed on a 10MHz counter without overflowing. For use with a counter with a 1MHz top frequency, you should cut the two links, and rewire them to the lower positions. This will provide a choice of divide-by-1000 and divide-by-10000.

The selected output is routed through S1b, to the remaining section of IC2. This section is strapped as an inverter and used as an output buffer.

Careful Construction

I built my version using single-sided copper-clad fibre glass p.c.b. material for cheapness. This needs careful layout and construction, because it's working with signals up to 1.2GHz. Fortunately, only the short track from the input socket to IC1, via C1 and C2, has to work at up to 1.2GHz.

The p.c.b. layout, with track diagram and component overlay, are shown in **Fig. 3** and **4**. The input track is soldered directly to the cut down centre conductor of the input connector. The connector is a BNC socket of the sort with a square mounting flange.

Two of the mounting screws carry solder tags. The ends of which are bent over at right-angles and soldered to the ground plane of the p.c.b., on either side of the input track.

Note that the link over the input track, is used to connect together the ground planes on either side of the input track. Support for the p.c.b. is provided by three bolts. In view of the small board area, these simple mounting arrangements are all that is necessary.

Aluminium Box

The case is a two-part aluminium box measuring 38 *x* 70 *x* 102mm, from Maplin Electronics (their ref: AB9). This provides adequate space to accommodate a NiCad type PP3 in addition to the p.c.b.

The output from the pre-scaler can either be by a flying coaxial lead or via another BNC socket. In the former case, it is best to limit the length of the lead to about 500mm, preferably using 75Ω coaxial cable. This is because the 75Ω type has less capacitance per millimetre than 50Ω coaxial cable.

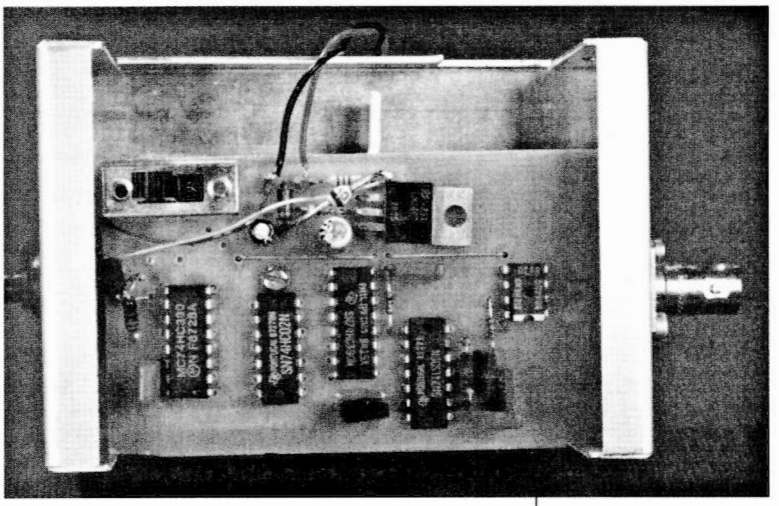
In the latter case, a short BNC to BNC lead is the best option. Again, the lead should be preferably of 75Ω coaxial cable, used to connect the pre-scaler to the counter or frequency meter with which it is to be used.

Construction Stages

Construction is best carried out in stages, testing as you go along. The diagram, **Fig. 4**, shows the component locations. To start, I suggest you first mount the components associated with the 7805 i.c. regulator.

Next, you should then check that 5.5V is available to power the other ICs. Now mount these, and check that the current drawn is about the expected amount.

You should note that along with many other pre-scalers, the SDA4212 i.c. will free run at a few hundred MHz, in the absence of an input. So you can expect to see a frequency of a few MHz at the output, on the divide-by-100 range.



Photograph showing the author's prototype pre-scaler.

The exact frequency will depend on the particular layout, the chip itself, and on whether the input is open-circuit or short-circuited. This effect is useful, as it provides a quick and simple check on whether the unit is basically functioning or not.

Prototype Performance

The prototype performance was verified by driving a Racal-Dana Universal Counter/Timer type 9500 via the pre-scaler, from a Racal-Dana Signal Generator type 9087.

The process was carried out at each of a number of frequencies from 1MHz to 1.2GHz. Starting with a largish output from the signal generator, the correct division ratio was verified by comparing the

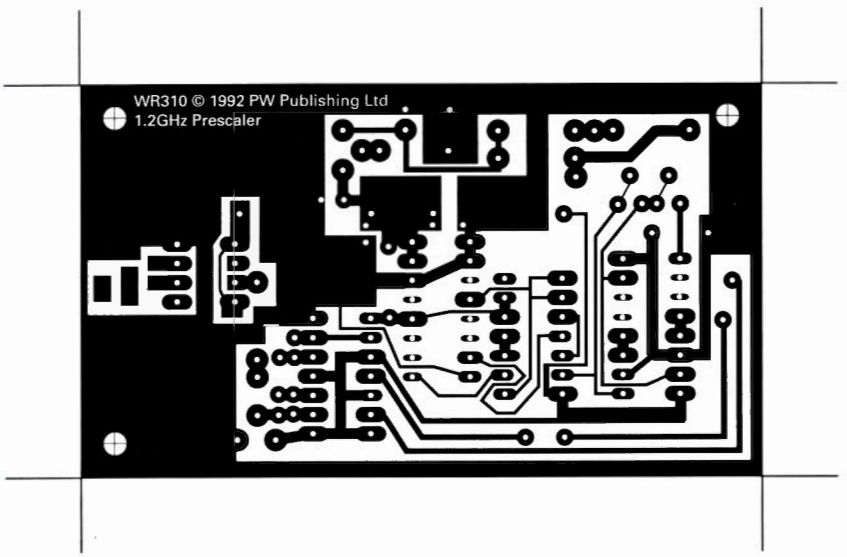


Fig. 3: The p.c.b. copper track design for the pre-scaler.

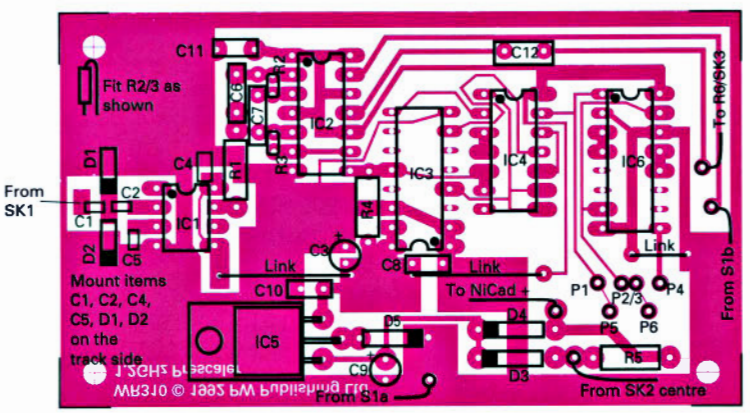


Fig. 4: Component side of the p.c.b., with component overlay provided to assist placing. The components marked as such, must be mounted on the copper track side of the p.c.b.

generator and counter digital read-outs.

During the evaluation, I steadily reduced the output until any further reduction resulted in miscounting. This level was taken as the sensitivity at that frequency.

My results showed that maximum sensitivity occurs at around 600MHz and that the sensitivity is considerably better than 10mV even at 1.2GHz. The unit is usable right down to 10MHz, though at this frequency the required input has risen to 14dBm or about 45mV.

The pre-scaler will even operate down to 1MHz, if it's pushed very hard. But in reality, the useful range can be taken as 10 to 1200MHz.

Reference 1. 'Simple Prescaler for Frequency Counters', R. Boensch, Siemens Components XXIII (1988) No. 3, page 123.

Miscellaneous

Suitable case (see text), p.c.b. (PCB Service), BNC input socket, coaxial cable, BNC plug. NiCad battery (see text), four-pole three-way switch. Power socket with change-over switching (to suit), battery connector, hardware. Connecting wire, wire for p.c.b. links.

How Much? **£20**
How Difficult? **Intermediate**

Shopping List

Resistors	
Carbon film 5% 0.25W	
33Ω	1 R6
220Ω	1 R1
820Ω	1 R5
2.2kΩ	1 R2
4.7kΩ	1 R3
10kΩ	1 R4
Capacitors	
Miniature chip (see instructions for placings)	
10nF	3 C1, 2, 3
Ceramic	
47nF	1 C4
Polyester	
0.1μF	6 C6, 7, 8, 10, 11, 12
Electrolytic 25V d.c. working	
10μF	1 C9
22μF	1 C3
Integrated Circuits	
SDA4212	1 IC1
74HC390	2 IC3, 6
74HC02	1 IC4
74LS00	1 IC2
7805	1 IC5
Diodes	
HP2800	2 D1, 2
1N4001	3 D3, 4, 5

Radio Diary

July 11: The Cornish Rally will be held at Penair School, St. Clement Hill, Truro. Usual amateur radio/electronic/computer traders, Bring & Buy, ample free parking, refreshments, vintage wireless display, RNARS, RAFARS, repeater groups, etc. Doors open 10.30am, disabled visitors 10am. Admission is £1, accompanied children under 16 free, otherwise 50p. Talk-in on S22, GX4CRC. Further details from **Mr Barrie Thomas G0NNR, 'Creekside', Greenbank Road, Devoran, Nr. Truro, Cornwall. Tel: (0872) 862046.**

July 12: The Horncastle Amateur Radio, Electronics & Computer Fair will be held in the Sports Hall of Queen Elizabeth's Grammar School, as last year. There will be facilities for a flea market outside, a talk-in station on 144MHz & there is lots of free parking. If anyone would like to bring things to sell from the boot of your car (electronics/radio only please), you will be able to, for a small fee. Any information can be obtained from **Tony Nightingale on (0507) 522482. or send an s.a.e. to The Area Youth Office, Horncastle Youth Centre, Cagthorpe Building, Cagthorpe, Horncastle, Lincs LN9 6HW.**

July 12: The Sussex Amateur Radio & Computer Fair will be held at Brighton Race-course. Trade stands, Bring & Buy, picnic area, refreshments, car park, free shuttle to Brighton sea front. For more details, phone **Robert Gornall (0424) 444466.**

July 19: The 9th McMichael Rally & Car Boot Sale will be held at the Haymill Youth & Community Centre, Burnham Lane, Slough (near Burnham Railway Station). The event starts at 10.30am, & admission is £1.50. The car boot sale (no advance bookings) is £6 per pitch on the day. There is free parking on site & talk-in is available on S22 (145.550MHz). For more details, contact **Neil G8XYN on Maidenhead (0628) 25952.**

July 19: The 2nd Wirral Rally will be held in the Masonic Hall, Manor Road, Liscard, Wallasey, Merseyside. Doors open 11am (10.30am for disabled). Details from **Dave Clifford G0NVF on 051-639 5922 & Darren Roberts on 061-476 3076.**

July 25/26: Norfolk ARS are planning a 2-day event. Details from **Sheila G0KWP. Tel: (0603) 618810.**

July 26: The Rugby ATS 4th Annual Amateur Radio Car Boot Sale will be held at the BP Truckstop on the A5, three miles east of Rugby & just two-and-a-half miles north-west from junction 18 of the M1 motorway. Dpen from 10am, admission is £1 per car & facilities include a good cafeteria & toilets. Talk-in on S22 by GB6CBS. Pitches are £7 pre-booked or £9 on the day. Further details from **Peter on (0455) 552449 or for bookings ring Kevin on (0203) 441590.**

July 26: Scarborough Amateur Radio Society will hold their Radio, Electronics & Computer Rally at the Spa, South Forshore, Scarborough. Doors open 11am. Many traders, Bring & Buy, refreshments & bar. Details from **Ian Hunter G4UQP on (0723) 376847.**

August 16: The Southend Rally will be held at The Rocheway Centre, Rochford, nr. Southend-on-Sea, Essex. Bring & Buy sale, bar & refreshments, ample parking. Talks in & out on SS2 v.h.f. For booking & other details, contact **John Stone G0DFE on (0702) 202216.**

August 23: The West Manchester Radio Club's 'Red Rose Rally' will be held at the Bolton Sports & Exhibition Centre, Silverwell Street, Bolton (town centre). All the usual trade stands, societies, Bring & Buy, etc. All at pavement level. Refreshments available all day & bar. Doors open at 10.30am for disabled & 11am for general public. Admission £1, children free. Further details from **Dave G1IOO on (0204) 24104 evenings only.**

August 30: The Galashiels Club are to hold their Open Day at the Focus Centre, Livingstone Place, Galashiels. All the usual activities, Bring & Buy, traders, club stalls & refreshments, etc. Doors open 11am until 4.30pm. More details from **John Campbell, 9 Brunton Park, Bowden, Melrose TD6 0SZ. Tel: (0835) 22686.**

August 31: Huntingdon ARS will be holding their Annual Rally & Junk Sale at the usual venue, the Medway Centre, Coneygeare Road, Huntingdon, Cambridgeshire. Doors open 10am until 4pm. Featuring trade stands, Bring & Buy, components, junk & their usual excellent refreshment bar. Car boot pitches available. Talk-in on S22 & GB3OV (433.125MHz). Details from **David Leech G7DIU on (0480) 431333.**

September 6: Preston ARS will be holding their 25th Annual Rally at the University of Lancaster, as in previous years. The university is located south of Lancaster & the entrance is on the A6 trunk road. From the M6 leave at junction 33 on to the A6 & proceed north for approximately three miles. Trade stands, club/repeater stands, large Bring & Buy, snack bar, lunchtime restaurant, licensed bar, free prize draw & free parking on campus. Doors open 11am (10.30am for disabled). Details from **George Earnshaw on (0772) 718175.**

September 6: Vange Amateur Radio Society will be holding their Annual Rally at The Laindon Community Centre, Laindon High Road/Aston Road, Laindon, Basildon, Essex. The centre is only a short walk from Laindon Railway Station on the Fenchurch Street to Shoeburyness Line. Doors open from 10.30am to 4.30pm. Admission 75p. Featuring many traders, Bring & Buy, refreshments & a free raffle. Talk-in on S22. Approach roads will be signposted. For further details contact **Mike Musgrave G4NVT on (0268) 543025 or Doris Thompson on (0268) 552606.**

September 6: Milton Keynes & DARS will be holding their 6th Car Boot Rally at Cranfield Airfield, (south side), Cranfield, Bedfordshire MK43 0AL (off J13 or J14 of the M1). Doors open 9.30am until 4pm. Hot & cold snacks & drinks, admission is 30p. Talk-in on S22, G8MKC. For further details, contact either **Ray G1LRU on (0908) 660798, Tony G6WXM on (0908) 316435 or Dave G3ZPA on (0908) 501310.**

September 12: The Scottish National AR Convention will be held at the Fife Institute of Physical & Recreational Education, Viewfield Industrial Estate, Glenrothes, Fife. Doors open 10.30am until 5pm. For further details, contact **John Hardwick GM4ALA on (0506) 410677 during office hours or otherwise on (0592) 742763.**

Attention rally organisers. We like to give your events all the publicity possible, but you can help us to help you by making the details as short as possible. Thank you!